A Review of the Impacts of Music and Implications for Music Medicine

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ABSTRACT

Music operates as a stimulus that arouses people's emotions and induces the release of neurotransmitters and hormones in the brain such as serotonin and dopamine. As such, music has many physiological effects including increased heart rate, blood pressure, and respiratory rate as well as impacts on mood. It also activates many networks in the brain, such as auditory neural pathways that process music and sensory circuits. Research has shown that involvement in musical activities have a noticeable impact on the intellectual, social, and personal development of children, catalyzing cortical reorganization and permanently altering how the brain processes information. Engagement in music learning and training, in particular, has been found to impact cognitive function and development. Though research has been conducted on these impacts, there has been little research comparing the impacts of listening to music on young adult musicians and non-musicians. Future research should investigate what these differences are to help inform the use of music medicine on patients of varying degrees of past and present engagement in music training and play.

Introduction to the Impact of Music

Although music is often thought of as a form of entertainment, field of study or practice, and for some an occupation, music has important impacts beyond what it offers in these conceptualizations. These impacts are variegated and have been researched for decades. Harvard Health (2021) mentions important impacts on health including impacts on the brain, the mind, stress, mood, movement, and even maladies for musicians. Through the mechanics of the transfer of sound, powerful music can act as a stimulus to activate the brain's reward center (Chen et al., 2022) to affect many aspects of health including memory, mood, heart function, and physical performance (Harvard Health Publishing, 2021). Listening to certain types of music has also been shown to improve cognitive performance, particularly spatial-temporal reasoning. The controversial "Mozart effect" first observed by Rauscher, Shaw, and Ky in 1993 refers to the unusual finding that listening to Mozart's sonata for 10 minutes led to short-term improvement in spatial reasoning tasks with 8-9 point increases in mean spatial IQ scores. Further research, however, has indicated that the effect is not as large as noted in the original study (Chabris, 1999) or not reproducible (Steele et al., 1999). Although the debate about the effects of listening to music on spatial IQ scores remains, what is clear is that music learning and training does impact cognitive function (Hallam, 2010).

Several studies have shown that music also relieves stress. Perioperative music, music played at around the time when surgeries are scheduled, have been found to reduce stress (Nilsson, 2008). For example, a sample of patients requiring cataract surgery was randomly selected to listen to music of their choice before, during, and after the procedure (Allen K et al., 2001). Observations of the patients' heart rates and blood pressures showed that patients who listened had a decrease in heart rate after an initial spike just before the surgery, whereas patients who were in silence throughout the procedure maintained a higher heart rate throughout the surgery. Studies have also found that the use of music-based interventions (MBI) can improve the mood of those with depressive disorders (Tang et al., 2020). Music is also helpful for improving mobility and movement. However, besides the many observed benefits of listening to music, music can also be maladaptive to musicians themselves. According to a Canadian study, the repetitive motions of playing instruments leave many musicians at risk of developing injuries stemming from overuse, especially of the arms. Musicians may also be at risk of hearing loss, as they are often exposed to loud music for long periods of time (Harvard Health Publishing, 2021).

The Impact of Music Training on Development

Research has also been done on the impact of involvement in musical activities on the intellectual, social, and personal development of children. Studies show that positive experiences with music can have many positive impacts on development, as musical activities can catalyze cortical reorganization and permanently alter the way the brain processes information (Hallam, 2010). Music has been shown to help children (Hirt-Mannheimer, 1995; Wolf, 1992), including those with learning disabilities (Humpal and Wolf, 2007), develop listening skills. This is due to the fact that music and speech have some common processing systems that allow musical experiences to impact language perception and therefore literacy. For instance, an experimental study involving children ages 4-6 found that a group provided with musical training for 25 minutes for 7 weeks showed EEG frequencies related to higher cognitive processing than compared to their control group (Flohr, Miller, and deBeus, 2000). Additionally, evidence suggests that musical instruction can help develop brain systems to better process and identify sounds and patterns in speech.

Musical activity has also been correlated to mathematics (Vaughn, 2000) due to the fact that musicians must use “quasi-mathematical processes” to interpret rhythmic notations and subdivide beats. Overall, studies on the relationships between music and math have yielded mixed results. A 1996 study (Geoghegan and Mitchelmore) showed that some children involved in musical activities scored higher on mathematics achievement tests than their control group counterparts, although home musical background could have been a confounding variable. In contrast, a 2003 study (Rafferty) found no significant improvements of mathematical achievement of second graders through musical involvement. Therefore, while evidence suggests that music can improve mathematical performance, there is still more research to be done on the nature of the relationship, the musical training needed, and the amount of training required.

There is also evidence to suggest that musical activities can lead to an increase in creative development. A 1969 study (Simpson) showed that music students in high school scored higher on multiple areas of Guildford’s tests of creativity compared to non-music students. Additionally, in 1982, Kalmer found that preschool children with musical instruction scored higher than controls on creativity and abstraction. Music participation has also been reported to be correlated to improved self-image and awareness (Whitwell, 1977). Music has also been shown to support physical development. Hallam (2010) states that rhythmic accompaniment to physical education improves performance. For example, studies by Painter (1966) and Anshel and Marisi (1978) showed that music helped improve performance in accuracy and endurance. Additionally, a 2001 study (Clift et al.) found that 50% of people in a university choir reported some form of physical benefit. Overall, music has been shown to have many benefits throughout development, from child literacy to physical and motor skills. However, more research must be done on the reasons why musical skills are applicable to other areas and what type and duration of music can best improve such areas.

The Impact of Music on the Heart

Music acts as a stimulus that can impact people’s emotions and therefore change heart activity, blood pressure, and breathing (Koelsch and Jäncke, 2015). While there have been many inconsistent findings, there are some consistencies. For instance, because heart rate is regulated by systems which are influenced by structures in control of emotions, such as the amygdala and hypothalamus, heart activity can be impacted by music that evokes emotions (Koelsch, 2014). Listening to music that brings out higher levels of emotional arousal tends to increase heart rate more than calming music, and exciting music has shown to increase respiratory rates (Koelsch and Jäncke, 2015) . However, there is no evidence that heart rate can change depending on musical beats (Ellis and Thayer, 2010). The change in heart rate from music-evoked emotions is related to music-evoked "frissions." These are highly pleasurable feelings most commonly described as goosebumps or chills (Sumpf, Jentschke, and Koelsch, 2015). Despite these findings, more research must be done to determine the specific effects (and their magnitudes) of music and music-evoked emotions on heart rate (Koelsch and Jacke, 2015).

Music has also been shown to reduce anxiety especially for patients with physical illnesses or patients about to undergo surgery and has been regarded as a viable alternative to sedatives or anti-anxiety medication. This is particularly relevant for patients with heart disease, as a reduction in anxiety is related to lower heart rates (Bradt, Dileo, and Shim 2013). While there has been data to suggest that music can also reduce pain perception, for instance an increase in oxytocin in response to soothing music after open heart surgery, the magnitude of reduction is small (Bernatzky et al., 2011). Additionally, many cardiovascular diseases are related to depression (Rugulies, 2002). Music has been proven to elevate mood through activating the body's reward system. Therefore, there is reason to believe that music can be used to treat depression and therefore the cardiovascular diseases related to depression (Maratos et al., 2008). However, research on the effectiveness of music in the treatment of depression is limited (Koelsch and Jacke, 2015).

The Impact of Music on Breathing

Research also shows that music can influence breathing rate. A 1996 study on the impact of arousal on breathing rate found that music influences respiratory rhythm (Shea, 1996). Research has shown that listening to calming music can have reducing effects on respiratory rate (Iwanaga et al., 1996), as a person's respiratory rate can vary depending on the tempo and structure of the music (Bernardi et al., 2006; Bernardi et al., 2009; Gomez and Danuser, 2007). Additionally, when participants listened to dissonant music from Stockhausen, their rate of breathing was more irregular and faster than when they listened to melodic music from Chopin (Noguchi et al., 2012). The change in respiratory rate of people who listen to music can strongly be correlated with music's impacts on emotions. A part of the brain that greatly impacts breathing rate is the limbic system, which plays a significant role in regulating a person's emotions. Thus, listening to Stockhausen's music elicited negative emotions that activated the amygdala, which resulted in increased respiratory rate as a response related to defense mechanisms. Contrastingly, decreases in anxiety amongst relaxed individuals were found to be associated with decreases in breathing rate (Noguchi et al., 2012).

The Impact of Music on the Brain

Music has also been proven to have significant impacts on the circuitry and waves of the brain. In fact, frequent music-listening can help activate neural pathways and synapses (Geethanjali et al., 2018). Through electroencephalography (EEG), it has been discovered that music directly influences brainwaves. Alpha EEG activity is the activity of the brain when at an awake but relaxed state (Zani et al., 2020). Pleasant music decreases alpha power in the left frontal lobe while unpleasant music decreases alpha power in the right frontal lobe. Additionally, a study found that listening to enjoyable music of choice allowed participants to be more vigilant while performing a mental task (Geethanjali et al.,2018). Additionally, music impacts the brain by activating many networks in the brain. There are connections between auditory neural pathways that process music and other brain circuits such as the brain's reward system, sensory circuits, motor pathways, etc. (Chen et al., 2022). Upon observing participants asked to listen to five excerpts of music, researchers found that the brain regions responsible for auditory and semantic processing, memory retrieval, and motor areas were all activated (Wu et al., 2019). A study also found that older adults who were musically trained for at least 10 years performed better on executive function and nonverbal memory tests than older adults without musical training, indicating that music training may exercise and positively impact those areas of the brain (Hanna-Pladdy and MacKay, 2011). The fact that music can trigger emotions also shows that music can impact the brain. According to neuroimaging and electrophysiological studies, music can alter neural systems in the human brain that not only deal with auditory and motor processing, but also those that regulate homeostasis and emotions, such as the amygdala, ventral striatum, etc. (Habibi and Damasio, 2014).

Music Medicine

Music therapy can be defined as the clinical use of music in order to improve physical, emotional, mental, and socio-cognitive wellbeing (American Music Therapy Association [AMTA], 2018). Music therapy requires the presence of a therapist to provide personally tailored treatment plans utilizing music, whereas "music medicine" is the use of music in clinical settings without a therapist (Bradt et al., 2015). There are implications that can be drawn from the impacts of music for music medicine. Recently, much research is being done on the therapeutic benefits of music and music-based interventions on the lungs, the brain, and mood.

There has been increased research on music interventions for conditions related to breathing and the lungs. Numerous studies have found both psychological and physiological benefits of choral singing for patients with chronic obstructive pulmonary disease (e.g., Bonilla et al., 2009; Lord et al., 2012; Lewis et al., 2016), and music has also been used in many clinical settings for pain management (Nilsson, 2008; Spintge, 2007), though Frishen et al. (2022) has noted that there has not been enough research related to breathing-related responses of those suffering from chronic lung diseases to music listening. Additionally, a 2020 analysis on adults with chronic obstructive pulmonary disease who were hospitalized and treated with music therapy found that music therapy significantly relieved dyspnea (i.e., shortness of breath) and helped reduce anxiety levels (Huang et al., 2020).

Music is also known to have many physiological effects such as increased heart rate, blood pressure, respiratory rate, etc. Altenmüller and Schlaug (2020) found that these effects stem from emotional responses to music in the brain. Music-induced emotions were also found to influence levels of neurotransmitters and hormones in the brain such as serotonin and dopamine that can contribute to the application of neurologic music therapy. Additionally, music's ability to connect with numerous systems in the brain allows it to be used to treat neurological disorders. For instance, music therapy has been found to be particularly effective in treating Parkinson's Disease (Chen et al., 2022). The human capability to detect rhythm is a primary contributor to the positive effects of music on motor neurological disorder, which includes normalizing gait in Parkinson's Disease. A 2021 review (Sotomayor et al.) found through numerous studies that music therapy programs can help improve various areas of difficulty for people with Parkinson's Disease including motor, socio-cognitive, and emotional spheres. Music therapy and other music-based interventions have also been effective in assisting the treatment of other neurological issues through, for example, assisting language recovery in stroke patients and helping those with dyslexia process phonological components (Chen et al., 2022).

Music has also been found to have an impact on people's mood, leading to research on music-based interventions for stress and anxiety, depression, etc. Listening to music has been strongly correlated to reducing stress by decreasing physiological arousal. This can be seen through reduced heart rate and arterial pressure and reduced cortisol levels (Burrai et al., 2016). As a result, music has often been used in clinical settings to reduce stress for patients. This type of music utilization is known as "music medicine" (Agres et al., 2020; Bradt et al., 2013; de Witte et al., 2020). For instance, a 2009 study found 'music medicine' decreased the need for morphine and provided "calm and relaxing" effects for children in post-operative care (Nilsson et al., 2009). Music has also been used as a form of therapy involving a therapist. Music therapy, which is provided by a licensed music therapist has also been used in many applications including mental health (Agres et al., 2020). A 2020 paper found that music therapy significantly decreased depressive symptoms in the experimental group (Tang et al., 2020). Additionally, music therapy has been utilized to treat patients suffering from depressive disorders and anxiety related to chronic illnesses. According to an article written in 2023, deaths of patients suffering from cancer can stem from psychological causes rather than just physiological. Many patients with cancer diagnoses often experience depression and anxiety related to their illnesses, but music therapy has been proven to be significant in treating such psychological issues (Eseadi and Ngwu, 2023).

The Differential Impacts of Music on Musicians vs. Non-Musicians

Although much research has been done on the impacts of music and music medicine on the body, there has been little research comparing the vital statistics of young adult musicians listening to music and non-musicians listening to music. Furthermore, while one study suggested that brain activity of those who have musical training differs from those who do not have musical training, that study was limited to female musicians with long training periods (19 ± 1 years on average) (Seung et al., 2005). Therefore, future research should 1) asses the differences in blood pressure, oxygen levels, heart rate, and brain activity between young adult musicians and non-musicians 2) determine the differences in reported emotions and stress levels and 3) draw implications regarding the potential effectiveness of music medicine on trained young-adult musicians and non-musicians based on the data collected.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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